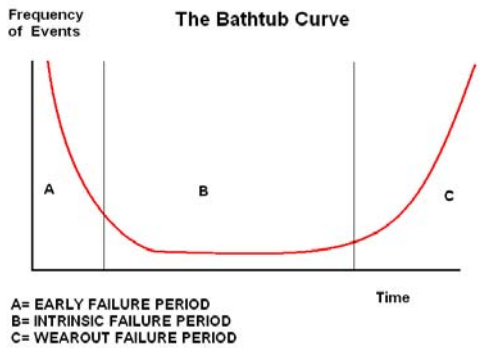
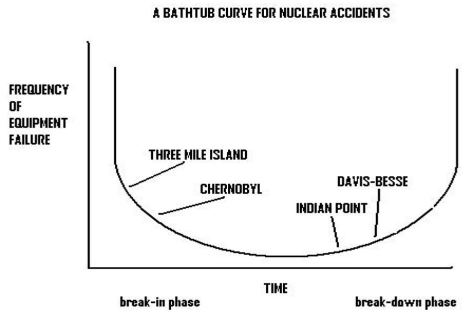
Engineering 101:
Toasters or Nuclear Power Plants





A Brief on Incidents at the Calvert Cliffs Nuclear Power Plant
(compiled by Chesapeake Safe Energy Coalition, November 2007)

The public rarely hears about safety breaches at nuclear power plants, however those that monitor and document these events, such as Nuclear Safety Engineer David Lochbaum at the Union of Concerned Scientists, are all too familiar with the inherent risks of the structures that generate electricity from the fissioning, or splitting, of uranium and plutonium atoms. Lochbaum maintains that an old nuclear reactor and a new nuclear reactor both face significant safety challenges or increased risks of accidents. The rate of incident for an old reactor is increased due to age related degradation. New reactors face unexpected or unforeseen design flaws, or "bugs" in the system that have not been worked out yet. When old and new reactors are sited together, the risk of incident increases for that site. Before Constellation Energy proposes to increase the risk for Calvert and surrounding counties, they should address the irreparable flaws in the emergency plan for the 10-mile radius evacuation zone.

The data and accounts presented serve to challenge the "sterling safety" record touted by local Calvert County officials, to disclose the Calvert Cliffs specific incidents that are a part of the aggregate report that serves as the basis for the "Bathtub Curve" theory, (pictured above) so-called because of the shape of the curve on the graph, and to emphasize the increased risk inherent in the proposed new reactor in Calvert County.

Compiled from "Fission Stories: Nuclear Power's Secrets" by David Lochbaum of Union of Concerned Scientists.

Calvert Cliffs Flooding

Owners of the Calvert Cliffs plant (PWR) in Lusby, Maryland learned in 1983 that the watertight integrity of the service water pump rooms on both units could be impaired if there was a pipe break or a flood. This undesirable condition occurred because check valves had not been installed in the floor drain system which carries water by gravity to the turbine condenser pit in the turbine building. Check valves are like the hinged doors on some buildings that easily open in one direction, but cannot open in the other direction. Check valves, when functioning properly, open to allow flow in one direction but close to prevent flow in the reverse direction. Each unit at Calvert Cliffs has a room in the auxiliary building where its three service water pumps are located. Both units share a common turbine building so that both of the service water pump rooms would be affected by flooding of the turbine building if backflow protection was not provided.

The relative elevations of the turbine building or a flood could fill the turbine condenser pit and result in 15 feet of water in both service water pump rooms. Although instrumentation would detect and annunciate an increase in water level in the turbine pit and the service water pump rooms, there would be no way to stop the flow of water in the event of a flood. Thus, the operators would know about the problem, but would be helpless to do anything about it. A loss of service water flow would affect the four containment air coolers for each unit and all three emergency diesel generators at the site.

If containment cooling via the air coolers is lost, containment heat removal and pressure control following a loss of coolant accident can be accomplished with the containment spray system. The containment spray is pumped through the shutdown cooling heat exchanger and transfers heat to the component cooling water system. The latter system is not affected by the postulated flooding. However, if the service water pump rooms flooded at the same time as there was a loss of offsite power, both units would experience a total loss of AC power, since cooling for all the emergency diesels at the site would also be lost.

This problem was resolved by sealing some of the drain lines and installing check valves to prevent backflow from the turbine building to the service water pump rooms.[1]

Both units at Calvert Cliffs had been operating for over six years when this design problem was discovered. Luckily, the plant did not experience a pipe break or flood during these years when it was inadequately protected.

Precursor to Disaster

(courtesy of Michael Mariotte Executive Director of the Nuclear Information and Resource Service)

On February 17, 1987, the entire emergency core cooling system (ECCS) was mistakenly disabled while the reactor was undergoing low power testing (basically what happened at Chernobyl). A technician realized that the entire ECCS wasn't supposed to be disabled, and ran down several flights of stairs to manually turn part of the system back on.

Clueless at Calvert Cliffs

The operators at the Calvert Cliffs Unit 1 facility (PWR) in Maryland started up the plant on the Fourth of July 1988 following a refueling outage. During the outage, the plant's owner had changed its reactor core to a low leakage configuration. This revised reactor core loading reduced the number of neutrons which "leaked" from the nuclear fuel. The result was improved fuel economy and less embrittlement of the reactor vessel from leaking neutrons.

When the nuclear instrumentation showed the plant running at about 39 percent power, the computer reported that the power level was 42 percent. To check the computer, an operator manually calculated the reactor power level. This hand calculation also reported 42 percent power. The nuclear instrumentation, which had been used during the startup, was reading much lower than the plant's actual power level. The nuclear instrumentation was recalibrated and then operators reduced the plant back to an actual power level of 30 percent for testing.

The large discrepancy was caused by the revised core loading pattern. The nuclear instrumentation relied on ex-core neutron detectors mounted outside the reactor vessel. The reduced neutron leakage meant that fewer neutrons reached the ex-core detectors for a given power level than in the past. The ex-core neutron detectors had not been core design. As a result, the plant started up with indicated power much lower than actual power. The error also meant that some of the plant's automatic protective features were non-conservatively set.

While glitches like this can occur, it is difficult to understand how it happened at Calvert cliffs Unit 1 in 1988. The very same core loading change had been made on Calvert Cliffs Unit 2 in 1987 and that plant restarted without incident.[2] An institutional memory of greater than a few months would be delightful.

Even without making the same change on Unit 2 during the previous year, there should have been plenty of reason for the folks at Calvert Cliffs to suspect this problem and catch it sooner. Nuclear plants

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[1] Nuclear Regulatory Commission, Information Notice No. 83-44, "Potential Damage to Redundant Safety Equipment as a Result of Backflow Through the Equipment and Floor Drain System," July 1, 1983.

[2] Institute of Nuclear Power Operations, Case Study INPO 89-007, "Material for a Case Study on Reactivity Mismanagement," May 1989.

are licensed by the NRC to operate up to a maximum thermal power level. At Calvert Cliffs, that limit on reactor power output is 2,700 megawatts thermal (Mwt). The plant can generate as much electricity as it can as long as the reactor power remains equal to or below 2,700 Mwt. Due to thermodynamic inefficiencies, nuclear plants can only convert about one-third of their thermal power into electrical power. The Calvert Cliffs plants are rated at 825 megawatts electrical (Mwe). The calibration problem at Calvert Cliffs Unit 1 did not, and could not have, affected the meter indicating electrical power. That meter looks just like the kilowatt-hour meter installed on homes to track electricity consumption. At the plant, it tracks electricity generation.

During this incident at Calvert Cliffs, when the plant was actually operating at 42 percent thermal power, it was only indicating about 30 percent thermal power. That discrepancy was explained by the ex-core neutron monitor mis-calibration. But the plant's electrical output at that time would have been somewhere around 350 Mwe. Its indicated thermal power was only 810 Mwt (i.e., 30 percent of 2,700 Mwt). The plant's efficiency would have been around 43 percent (i.e., 350 Mwe divided by 810 Mwt). The laws of thermodynamics do not allow such a high efficiency for the pressure and temperature conditions of modern nuclear power plants. The unusually high efficiency should have piqued considerable interest as soon as the generator was placed on line. The generator was on line before the plant reached the 30 percent actual thermal power level, yet the Calvert Cliffs folks didn't notice, or didn't respond to, the impossible conditions.

Three Strikes and You're Out (of Alarms)

On February 1, 1988, all control room annunciator alarms at the Calvert Cliffs Unit 2 facility (PWR) in Maryland failed. There was a fire in a remote annunciator cabinet which was extinguished by the automatic actuation of the fire protection system. The audible alarms were out of service for two quiet days.[3]

Compiled from research done by David Lochbaum

Nearest Nuclear Near-Misses at Calvert Cliffs

April 13, 1978- Unit 1-Odds[4]: 208.33

With the reactor shut down, the switchyard breakers opened causing a loss of offsite power. Both emergency diesel generators were signaled to start. EDG 11 failed to start for undetermined reasons. EDG 12 automatically started and connected to its safety-related electrical bus.

April 13, 1978-Unit 1-Odds: 333.33

With the reactor shut down, a protective relay automatically opened the switchyard output breakers, resulting in a loss of offsite power. Emergency diesel generator (EDG) 11 failed to start. EDG 22 started and supplied power to the safety buses.

July 23, 1987- Unit 2-Odds: 2083.33

[5]Loss of offsite power lasting 118 minutes caused by faults on a transmission line from tree contact.

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[3] Nuclear Regulatory Commission, Information Notice No. 88-05, "Fire in Annunciator Control Cabinets," February 12, 1988.

[4] Odds from NRC reports of how likely can lead to reactor meltdown. The value represents how often such an event would result in a meltdown. For example, a value of 50 means that, on average, a meltdown will occur once every 50 years.

[5] The risk of major accident associated with this event is 1 in 2,000 (also noted in the Greenpeace report), which is actually very high. NRC's usual standard for safety is to keep risks less probable than 1 in 1,000,000. In addition, the NRC has admitted that loss of offsite power represents 50% or more of the risk of a meltdown at a commercial nuclear power reactor in the U.S. Of course, when offsite power is lost, not only does the clock start ticking towards meltdown (especially if the emergency diesel generators fail to work, which happens all too often at US reactors), but the emergency sirens won't work when needed most – As of 2005, Calvert Cliffs' sirens have no back up power in the event of loss of power from the grid.

July 23, 1987-Unit 1-Odds: 2083.33
Loss of offsite power lasting 118 minutes caused by faults on a transmission line from tree contact.

Additional incidents recorded by Jim Riccio of Greenpeace from the report, An American Chernobyl: Nuclear Near Misses at U.S. Reactors Since 1986

January 12, 1994 Unit 2 -1.30E-05[6]
Reactor Trip With Complications

May 16, 2001 Unit 1 -1.00E-05
Auxiliary Feed Water (AFW) Pump Failed

January 4, 2004 –Unit 2 -2.00E-05
Reactor Trip With Complication

The Consequences of Reactor Accident (CRAC-2) Report

In 1982, the Nuclear Regulatory Commission released a report entitled, The Consequences of Reactor Accident (CRAC-2). The report examined the downwind consequences of a reactor meltdown for all the reactors operating at that time. The "consequences" are quantified in four categories; peak early fatalities, peak early injuries, peak cancer deaths, and property damage.

The assessment conducted by the Nuclear Regulatory Commission details in numbers the horror of reactor meltdown. This potential horror begs the question, "Is it worth it?"

[7]Calvert Cliffs Nuclear Power Plant

Peak Early Fatalities
Unit 1 - 5,600
Unit 2 - 5,600

Peak Early Injuries
Unit 1 - 15,000
Unit 2 - 15,000

Peak Cancer Deaths
Unit 1 - 23,000
Unit 2 - 23,000

Property Damage*
(in Billions-1982 $)
Unit 1 - $87.4 Billion
Unit 2 - $92 Billion

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[6] For those accidents that did not result in core damage the NRC assess a probability expressed as a negative function. So an accident with a probability of 1 X 10-1 has a one in ten chance of causing core damage. To simplify the risk equation, the scientific community and the NRC's risk analysts use E to represent X10.

[7] Both the population density increases since 1982, as well as adjusting for inflation from 1982 dollars to 2007 dollars, needs to be accounted for as well. And note that if both reactors were to melt down simultaneously (such as by "common mode failure," such as loss of offsite power to run safety and cooling systems, or even a terrorist attack), you'd have to add up those figures for each reactor to get the sum total.